

# PATENT SPECIFICATION

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## (54) STEEL-PIPE COATING PROCESS AND APPARATUS

(71) We, KOBE STEEL LTD., a joint stock company, organised under the laws of Japan, of 3-18, 1-chome, Wakinohama-cho, Fukiai-ku, Kobe-city, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 This invention relates to a method of and an apparatus for coating a steel-pipe, in which molten resin is extruded through a cross head die connected to an extruder, to form a tube, in such a way as to cover the outer surface of a steel pipe, and more particularly to a method and apparatus in which the amount of resin being extruded through a cylindrical outlet in the cross head die around the surface of the steel pipe may be intermittently varied, thereby forming nodes in the resin coating covering the surface of the steel pipe.

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Various methods have been proposed for forming nodes, i.e., annular ribs on a resin coating covering the surface of a steel pipe, to give it an appearance like that of bamboo. Three particular proposals are as follows:

25 (a) A method of coating the surfaces of a steel pipe by using a cross head die in an extruder, in which the feeding of a steel pipe is intermittently interrupted, so that resin being fed from the cross head die is intermittently built up in specific positions around the surface of the steel pipe, thereby forming annular ribs therearound;

30 (b) A method in which an extruder and a cross head die are formed as one body and the extruder and cross head die are jointly reciprocated with a given stroke, and the speed of reciprocation of the extruder and cross head die relative to the steel pipe being fed is intermittently varied so as to form annular ribs around the surface of the pipe;

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(c) A method which uses a main extruder for extruding resin for use in coating, and an auxiliary extruder for extruding resin to form ribs.

45 However, in method (a), the feeding of the steel pipe is intermittently interrupted, so that a coated steel pipe is not formed continuously. This method is inefficient and not suitable for mass production.

50 In method (b) the joint reciprocation of the extruder and cross head die necessitates the use of a large scale apparatus, with the accompanying increase in power requirements and installation cost. In method (c) two extruders are required, resulting in an 55 increase in the size of the apparatus and the installation cost.

60 It is accordingly an object of the present invention to provide a simple and efficient method of and an apparatus for coating a steel-pipe, which may avoid the shortcomings encountered in the prior art methods and apparatuses, the steel pipe being fed continuously, and annular ribs being formed in the resin coating at specific positions along the steel pipe.

65 According to the invention there is provided an apparatus for coating a steel pipe comprising an extruder for continuously extruding a resin for coating the steel pipe, and a cross head die having a resin inlet, a steel pipe guide passage, and a resin extruding outlet surrounding the steel pipe at the exit of the steel pipe guide passage, wherein the extruder is rigidly secured to a 70 fixed frame; the resin extruding outlet in the extruder communicates through a resin guide member with the resin inlet in the cross head die, thereby to introduce a coating resin from the extruder into the cross head die; and the cross head die is mounted in such a manner as to be reciprocatable with 75 respect to the frame by means of a reciprocating drive means through a given stroke

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in the axial direction of the steel pipe guide passage.

The apparatus can be used to form annular ribs at a given pitch on a resin coating covering the outer surface of the steel pipe.

The resin guide member may be a hose or other member having a degree of flexibility. Alternatively, the resin guide member may be an expansion-and-universal joint affording suitable expansibility. The resin guide member may include an adaptor which communicates with the resin outlet of the extruder, and an annular member which is fitted in and supported by the cross head die in slidable relation thereto.

The reciprocating drive means for reciprocating the cross head die may be provided with a mechanism, such as a brake and a clutch, for temporarily interrupting the aforesaid reciprocating movement of the cross head die.

The invention also provides a method of continuously coating the surface of a steel pipe with resin, wherein a molten resin is extruded from a cross head die coupled via a resin guide member to an extruder rigidly secured to a fixed frame, into a tubular form over the surface of the steel pipe, thereby continuously coating the surface of the steel pipe with resin, wherein the process comprises the steps of reciprocating the cross head die with respect to the fixed frame through a given stroke axially, of the steel pipe at predetermined timings during the coating operations, thereby intermittently varying the relative speeds of the steel pipe and the cross head die, so as to intermittently vary the amount of resin being extruded over the surface from the cross head die, whereby the resin is intermittently built up on the surface of the steel pipe in the form of ribs.

Fig. 1 is a front view of one embodiment of the present invention;

Fig. 2 is a longitudinal section taken along the line II-II of Fig. 1;

Fig. 3 is a horizontal, partially cross sectional view taken along line III-III in Fig. 1.

Fig. 4 is a plan view of a reciprocating drive means taken along line IV-IV in Fig. 1.

Fig. 5 is a plan view of an alternative embodiment of reciprocating drive means;

Figs. 6A and 6B are horizontal sectional views of two alternative forms of resin guide member; and

Figs. 7 and 8 show other embodiments having other forms of resin guide member; and

Fig. 9 is a plan view of the apparatus shown in Fig. 8.

One embodiment of the invention will

now be described in more detail with reference to Figs. 1 to 6. Figs. 1 to 3 show an extruder 1 for supplying a coating resin B, the extruder 1 being rigidly supported on a fixed frame 21. The extruder comprises a cylindrical barrel 11 and a screw 12. An adapter 14 is secured to the end of the barrel 11 via a breaker plate 13 having a plurality of bores 131. An expansion and universal joint 3 serves as a resin guide member, which brings a resin extruding outlet 141 provided in the adapter 14 into communication with a resin inlet 411 provided in the cross head die 4. The joint 3 comprises an inner cylinder 31 and an outer cylinder 32 which is slidably and telescopically fitted on the cylinder 31 longitudinally thereof. The inner cylinder 31 has an intermediate flow passage 311 in its centre, and is formed with a spherical portion 312 at one end thereof. The spherical portion 312 is rotatably received in the adapter 14 by a holder 33 and a fixed plate 34. The outer cylinder 32 has an intermediate flow passage 322, a chamber 321 which receives the inner cylinder and a spherical portion 323 at one end thereof. The spherical portion 323 is rotatably received in the cross head die 4 by means of a holder 35 and a fixed plate 36, with the inner cylinder 31 being slidably received in the chamber 321. As a result, the resin outlet 141 in the adapter 14 is in communication via the intermediate flow passages 311 and 322 in the inner cylinder 31 and outer cylinder 32, with the resin inlet 411 in the cross head die 4.

Alternatively, the outer diameter of the cylinder 32 may be the same as that of the cylinder 31, cylinder 31 being connected to the cylinder 32 by an annular member 38 which is received on the outer periphery portion of both cylinders, as shown in Fig. 6A so that the cylinder 32 moves slidably in the annular member. Yet another alternative is for the adapter 14 to communicate through a flexible hose 37 with the cross head die 4 as shown in Fig. 6B. The hose 37 preferably possesses heat and pressure resistance and flexibility.

The cross head die 4 is formed with a bore 412 extending at a right angle to the resin inlet 411. A liner 42 is inserted in the bore 412, and has a die 43 at its tip. The liner 42 includes a central guide passage 421 for a steel pipe A. The liner 42 has a tip portion 422 which is cylindrical and has a reduced thickness, the die 43 being fitted around the tip portion 422 to define a cylindrical resin-extruding outlet 426. The cylindrical outlet 426 communicates with the resin inlet 411 through a channel-like passage 423 defined around the peripheral surface of the liner 42, a cylindrical passage 424 defined between a side portion of the liner 42 and the cross head die and a

tapered passage 425 defined between the liner 42 and the cross head die 4. The cross head die 4 is supported so as to be reciprocatable through a given stroke in the direction of the steel pipe A being fed, by means of a reciprocating drive means 6. More particularly, a pair of upper and lower guide members 52, 53 are secured via two or more rods 51 to the adapter 14, while a pair of upper and lower supporting members 44, 45 are secured to the cross head die 4. A plurality of guide rollers 54, 55, 56, 57 are fitted on vertical and horizontal shafts extending from the supporting members 44, 45, respectively, and rotatably engage guide grooves 521, 531 in the guide members 52, 53 thereby supporting the cross head die 4 so that it is reciprocatable through a given stroke in the direction of a steel pipe being fed. Tubular covers 511 are provided for the rods 51.

A bar 61 is coupled to the cross head die 4, and has a roller 62 which is rotatably fitted on a shaft 621 at the tip thereof. The bar 61 has a projecting shaft 611 at the rear end thereof, the projecting shaft 611 being slidably supported by a bracket 63 which in turn is secured to a frame 631 projecting from the rear end of the guide member 53. A compression spring 64 is confined between the bracket 63 and the rear end of bar 61. The spring 64 resiliently urges the roller 62 against a cam surface 651 of a cam plate 65. The cam plate 65 is secured to a shaft 66, which in turn is supported via a bearing 67 on a supporting frame 22 positioned in parallel with the fixed frame 21, and coupled by a coupling 682 to a drive shaft 681 of a geared motor 68 having a gear transmission. As shown in Fig. 5, a clutch brake 69 and an r.p.m. detector 91 are provided on a shaft 681 for interrupting the rotation of the cam plate 65 temporarily.

Band heaters 71, 72, 73, 74, 75, 76 are attached to the outer peripheries of the barrel 11, the adapter 14, the cylinders 31 and 32 of the expansion-and-universal joint, and cross head die 4, respectively.

Fig. 7 shows an alternative embodiment 50 of resin guide member. As shown in Fig. 7, the extruder 1 for a synthetic resin has an adapter 14 secured to the tip of a cylinder 11 via a breaker plate 13 having a plurality of bores 131, and provided with a resin extruding outlet 141. A first intermediate member 80 is coupled to the tip of the adapter 14 by fastening means (not shown), for example bolts. The first intermediate member 80 is integrally formed with a projecting upright first shaft 81 at the upper end thereof. An intermediate flow passage 83 runs through the first intermediate member 80 and the first shaft 81, and a resin inlet 82 of the flow passage 83 is open in a given position and communicates with the

resin extruding outlet 141. A resin outlet 84 of the flow passage 83 is open from the outer peripheral surface of the first shaft 81. Alternatively, the first intermediate member 80 may be formed separately from the first shaft 81 and removably coupled thereto.

As in the preceding embodiment there is an expansion-and-universal joint 3 which consists of an inner cylinder 31 and an outer cylinder 32 which is slidably fitted on the inner cylinder 31 longitudinally thereof. The inner cylinder 31 is provided with a central intermediate flow passage 311 and a bearing portion 312 at its one end, which portion extends at right angles to the inner cylinder 31. The first shaft 81 is fitted in a bore 313 defined in the bearing portion 312, so that the inner cylinder is rotatably supported about the first shaft 81, while the intermediate flow passage 311 communicates with the resin outlet 84. The outer cylinder 32 has a chamber 321 which receives the inner cylinder, an intermediate central flow passage 322, and a bearing portion 323 at one end, which portion extends at right angles to the outer cylinder 32. The inner cylinder 31 is slidably received in the chamber 321 along the length thereof in such a manner that the flow passages 311 and 322 communicate with each other. A second shaft 86 parallel with the first shaft 81 is fitted in a bore 324 defined in the bearing portion 323, so that the outer cylinder 32 is rotatably supported by the second shaft 86.

A second intermediate member 85 is secured to the cross head die 4 by means of fastening means such as nuts and bolts. The second shaft 86 is upright on the second intermediate member 85 and parallel to the first shaft 81, and an intermediate flow passage 88 runs through the second intermediate member 85 and the second shaft 86. A resin inlet 87 of the flow passage 88 opens from the peripheral surface of the second shaft 86 in a given position into communication with an intermediate passage 322 in the outer cylinder 32, and a resin outlet 89 of the flow passage 88 is open into communication with a resin inlet 411 provided in the cross head die 4. As a result, the resin extruding outlet 141 at the edge of the adapter 14 of the extruder 1 communicates with the resin inlet 411 in the cross head die 4, via the intermediate flow passage 83 in the first intermediate member 80 and first shaft 81, intermediate flow passage 311, 322 in the inner cylinder 31 and outer cylinder 32 in the expansion-and-universal joint 3, and the intermediate flow passage 88 in the second shaft 86 and second intermediate member 85. The second shaft 86 may be formed separately of the second intermediate member 85 and removably coupled thereto. The first intermediate

member 80 and second intermediate member 85 may be of shapes and constructions other than those illustrated. However, it is advantageous from a manufacturing viewpoint 5 for the shapes and construction of the members 80 and 85 to be identical. Crown nuts 810, 820 are shown for use with the expansion-and-universal joint 3, and nuts 810 and 820 being threaded on the upper 10 ends of the first shaft 81 and the second shaft 86, respectively. Washers 811, 821 are provided for reducing friction in the expansion-and-universal joint 3, upon rotation thereof. However, bearings may replace 15 these washers. The cross head die 4 and reciprocating drive means for the cross head die 4 are the same in this embodiment as in the preceding embodiment.

In the above-described embodiment, resin 20 guide members having flexibility or expansibility are described. Another embodiment of the invention is shown in Figs. 8 and 9. Fig. 8 shows an extruder 1 for extruding a synthetic resin, which is of the same construction as in the preceding embodiments. An adapter 14 having a plurality of bores 131 is attached to the tip of a barrel 11. An annular, cross-head outer member 90 is coupled to the tip of the adapter 14 by a 25 plurality of attaching bolts (not shown). Provided in the cross-head outer member 90 are a resin flow passage 91 communicating with a resin flow passage 141 provided in the adapter 14, and supporting bore 92 extending 30 at right angles to the flow passage 91. The cross head die 4 is slidably supported in the supporting bore 92. A key 46 is secured to the outer peripheral surface of 35 the cross head 4 in a given position by means of a bolt 47. The key 46 is slidably fitted in a key way 48 which extends in the horizontal direction as viewed in the drawing, so that the cross head 4 may slide only in the horizontal direction as viewed in the 40 drawing, i.e., in the direction in which the steel pipe A is fed, relative to the cross-head outer member 90. An outwardly divergent resin inlet 411 which communicates 45 with the flow passage 91, and a bore 412 running at right angles to the inlet 411 are provided in the cross head die 4. A liner 42 is inserted in the bore 412. In other ways the cross head die 4 is the same as in the preceding embodiment. A drive means 6 is provided for reciprocating the cross head 50 die 4.

A bracket 610 and the rear end of the liner 42 are coupled to the rear end of the cross head die 4 by means of a locating bolt 611 and a tightening bolt 612. A steel pipe inlet 613 is provided in the bracket 610 and communicates with the rear end of a steel pipe guide passage 421 in the liner 42. The bracket 610 is formed with an arm 614 at 55 the end of which a roller 616 is rotatably

supported on a shaft 615. A cam mechanism 700 comprises a cam plate 710 which is provided with a cam way 711, the roller 616 being rotatably received in the cam way 711. The cam way 711 includes an endless circumferential cross-head-stopping groove portion 712, and a projecting portion 713 which is adapted to move the cross head die and projects in the radial direction. The cam plate 710 is secured to a drive shaft 714 which is coupled to a drive means, for example a motor, not shown.

The cross head die 4 is reciprocated in the cross head outer member 90 due to the rotation of the cam plate 710, and resin B is forced from the extruder 1 through the resin flow passage 141 in the adapter 14, then through the resin flow passage 91 in the cross head outer member 90 into the resin inlet 411 in the cross head 4.

The operation of the apparatus according to the present invention will now be described with reference to Figs. 1 to 5.

Firstly, a steel pipe A is inserted into the guide passage 421, and fed to the right in the drawing at a predetermined speed by feeding and drawing means not shown. In line therewith, coating resin B is melted and kneaded in the extruder and continuously supplied into the cross head die 4 through the bores 131 in the breaker plate 13, a resin extruding outlet 141 in the adapter 14, and the intermediate flow passages 311 and 322 in the expansion-and-universal joint 3. Molten resin supplied into the cross head die is forced out from the inlet 411 into the flow passages 423, 424, 425 then into tubular extruding outlet 426 where it assumes a tubular form for coating or covering the surface of the steel pipe A. The inner diameter of the tube of resin B thus extruded is larger than the outer diameter of steel pipe A, so that there is some clearance therebetween. However, such a clearance may be eliminated by drawing air from the clearance by means of a vacuum pump (not shown), so that the tubular resin B may cover the surface of the steel pipe tightly.

During coating the cross head die 4 reciprocates in the horizontal, opposite directions  $a$  and  $a'$  as shown in Fig. 1, so that annular ribs  $b$  may be formed on the surface of the tubular coating B at a given pitch. More specifically, when the cam plate 65 is rotated at a given rotational speed by means of the motor 68, the cross head die 4 is reciprocated through a given stroke in the direction of the steel pipe being fed; by means of the roller 62, the bar 61 and the spring 64. At this time, the cross head die 4 is moved a given distance in the direction of the arrow  $a'$  at the same speed as a steel-pipe-coating speed, so that the relative speed of the coating being formed to 130

the pipe is zero. As a result the resin forced out from the tubular outlet 426 in the die 43 is built up at the outlet 426 in an amount proportional to the displacement of the cross head die 4, thereby forming an annular rib *b*. Thereafter, the cross head die 4 is moved in the direction *a* to return to its initial position, during which time resin is uniformly coated on the surface of the steel pipe over a length proportional to the returning time of the cross head die.

In this manner, synthetic resin *B* coats the surface of the steel pipe *A* which is being continuously fed at a given speed. Thus, when the cross head die 4 is reciprocated through a given stroke by means of the cam plate 65, the relative coating speed of the cross head die to the steel pipe being fed is maintained intermittently at zero, so that annular ribs *b* of a given size may be formed thereon at a given pitch one after another. The size, shape and, rotational speed of the cam plate 65 may be freely selected. The size of ribs *b* may be suitably adjusted by selecting a particular shape of the cam plate and the stroke of the cross head die 4. In addition, the spacing or pitch of ribs may be suitably adjusted by changing the shape and/or the rotational speed of the cam plate and by selecting the return time of the cross head.

If the coated steel pipe is to be sheared there may be a need to change the pitch of the ribs partially, so as to avoid the ribs *b* being positioned at a cutting position or closely adjacent thereto. For this purpose, the detector 91 detects the r.p.m. of the drive shaft 681 for the cam plate to issue an instruction to a clutch brake 69 for intermittently interrupting the rotation of the cam plate 65. In this manner, the spacing or pitch of the ribs *b* formed may be suitably changed, to avoid the ribs being positioned at a cutting position.

The drive means 6 for the cross head die in the above embodiment is provided by a cam mechanism. However, a crank mechanism or gear mechanism may be used as an alternative. In addition, the guide supporting mechanism may be replaced by other means.

As will be apparent from the foregoing description, the surface of a steel pipe may be continuously coated with resin while the steel pipe is fed at a given speed. In addition, annular ribs may be formed in a simple manner, so that the feeding of a steel pipe need not be stopped or slowed down, but may be continued without interruption. Accordingly, production efficiency may be improved, with an accompanying increase in output and a reduction in manufacturing cost.

In particular, since the extruder is used in a stationary condition, with the cross head

die being reciprocated so as to form an annular rib thereon, the size of reciprocating drive means for the cross head die may be reduced, the construction thereof may be simplified, and the cost of installation may be reduced. In addition, the size and pitch of ribs may be readily varied over a wide range.

#### WHAT WE CLAIM IS:—

1. An apparatus for coating a steel pipe comprising an extruder for continuously extruding a resin for coating the steel pipe, and a cross head die having a resin inlet, a steel pipe guide passage, and a resin extruding outlet surrounding the steel pipe at the exit of the steel pipe guide passage, wherein the extruder is rigidly secured to a fixed frame; the resin extruding outlet in the extruder communicates through a resin guide member with the resin inlet in the cross head die, thereby to introduce a coating resin from the extruder into the cross head die; and the cross head die is mounted in such a manner as to be reciprocatable with respect to the frame by means of a reciprocating drive means through a given stroke in the axial direction of the steel pipe guide passage.

2. An apparatus as claimed in claim 1, wherein the guide member is flexible.

3. An apparatus as claimed in claim 2, wherein the resin guide member is a hose.

4. An apparatus as claimed in Claim 1, wherein the resin guide member comprises an inner cylinder having an inner cylindrical body and a spherical portion positioned at one end of the inner cylindrical body and rotatably connected to the resin extruding outlet of the extruder, and an outer cylinder having an outer cylindrical body slidably mounted on the inner cylindrical body, and a spherical portion positioned at one end of the outer cylindrical body and rotatably connected to the resin inlet of the cross head die.

5. An apparatus as claimed in Claim 1, wherein the resin guide member comprises a first cylinder having a cylindrical body and a spherical portion positioned at one end of the first cylindrical body and rotatably connected to the resin extruding outlet of the extruder, a second cylinder having a cylindrical body and a spherical portion positioned at one end of the second cylindrical body and rotatably connected to the resin inlet of the cross head die, and an annular member mounted around the outer peripheral portions of the cylindrical bodies, the cylindrical bodies being slidable in said annular member.

6. An apparatus as claimed in Claim 1, wherein the resin guide member comprises a first intermediate member coupled by a

universal joint to the resin extruding outlet in the extruder, and having a resin passage, a second intermediate member coupled by a universal joint to the resin inlet in the 5 cross head die and having a resin passage, and a connection member telescopically connecting the said resin passages with one another for communication therebetween.

7. An apparatus as claimed in Claim 1, 10 wherein the resin guide member comprises an adapter coupled to the resin extruding outlet of the extruder, and an annular body connected to the adapter, the cross head die being slidably mounted in the annular body, 15 the annular body having a bore which communicates the resin passage in the adapter with the resin inlet in the cross head die.

8. An apparatus as claimed in any preceding Claim, wherein the reciprocating 20 drive means is provided with a stop mechanism for interrupting the reciprocating movement of the cross head die temporarily.

9. An apparatus as claimed in Claim 8 wherein the stop mechanism is a clutch and 25 brake means.

10. An apparatus for coating a steel pipe, substantially as herein described with reference to Figs. 1 to 4, with or without the modification of Fig. 5 and with or without the modification of Fig. 6A or 6B, of the 30 accompanying drawings.

11. An apparatus for coating a steel pipe, substantially as herein described with reference to Fig. 7, or Figs. 8 and 9 of the accompanying drawings.

12. A method of continuously coating the surface of a steel pipe with resin, wherein a molten resin is extruded from a cross head die coupled via a resin guide member to an extruder rigidly secured to a fixed frame, into a tubular form over the surface of the steel pipe, thereby continuously coating the surface of the steel pipe with resin, wherein the process comprises the steps of reciprocating the cross head die with respect to the fixed frame through a given stroke axially of the steel pipe at predetermined timings during the coating operation, thereby intermittently varying the relative speeds of the steel pipe and the cross head die, so as to intermittently vary the amount of resin being extruded over the surface from the cross head die, whereby the resin is intermittently built up on the surface of the steel pipe in the form of ribs.

13. A method of continuously coating the surface of a steel pipe with resin, substantially as herein described with reference to any one of the embodiments shown in the accompanying drawings.

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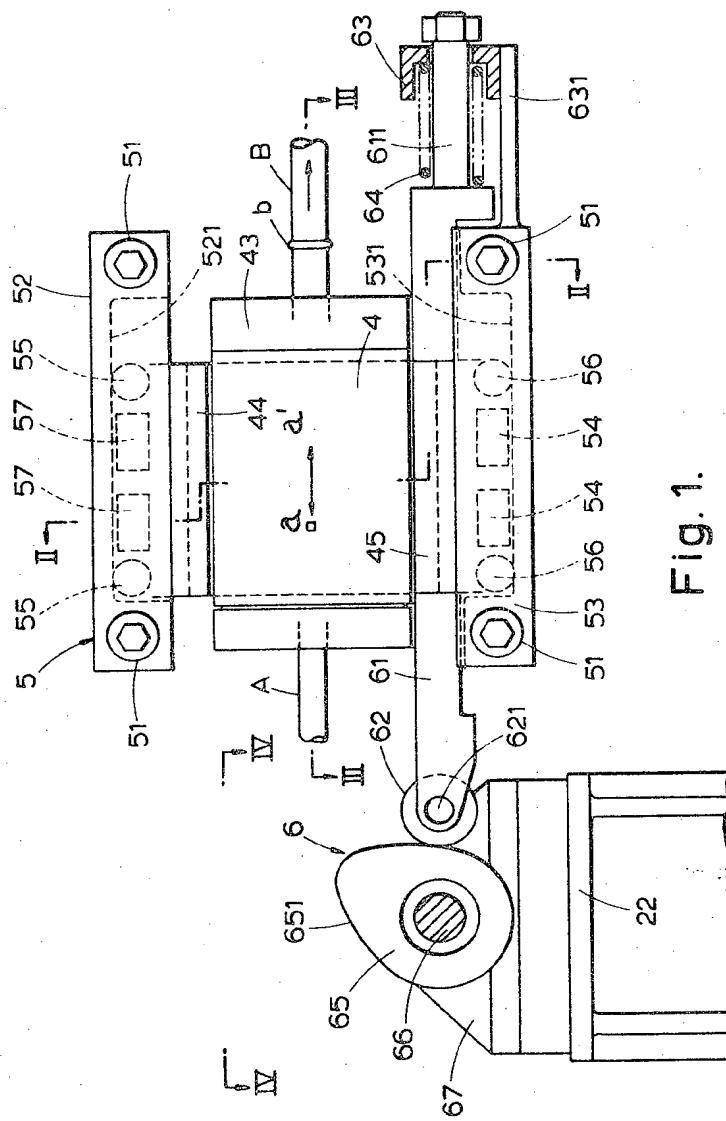


Fig. 1.

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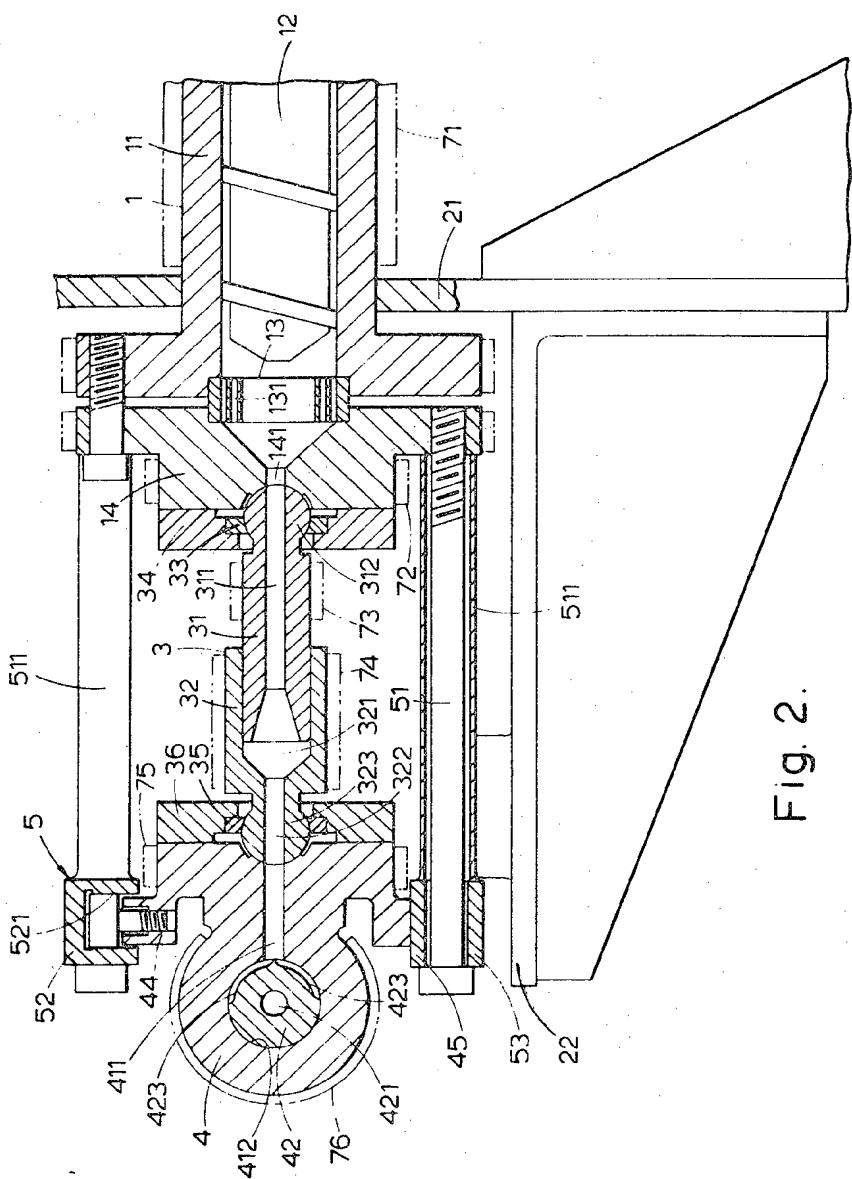
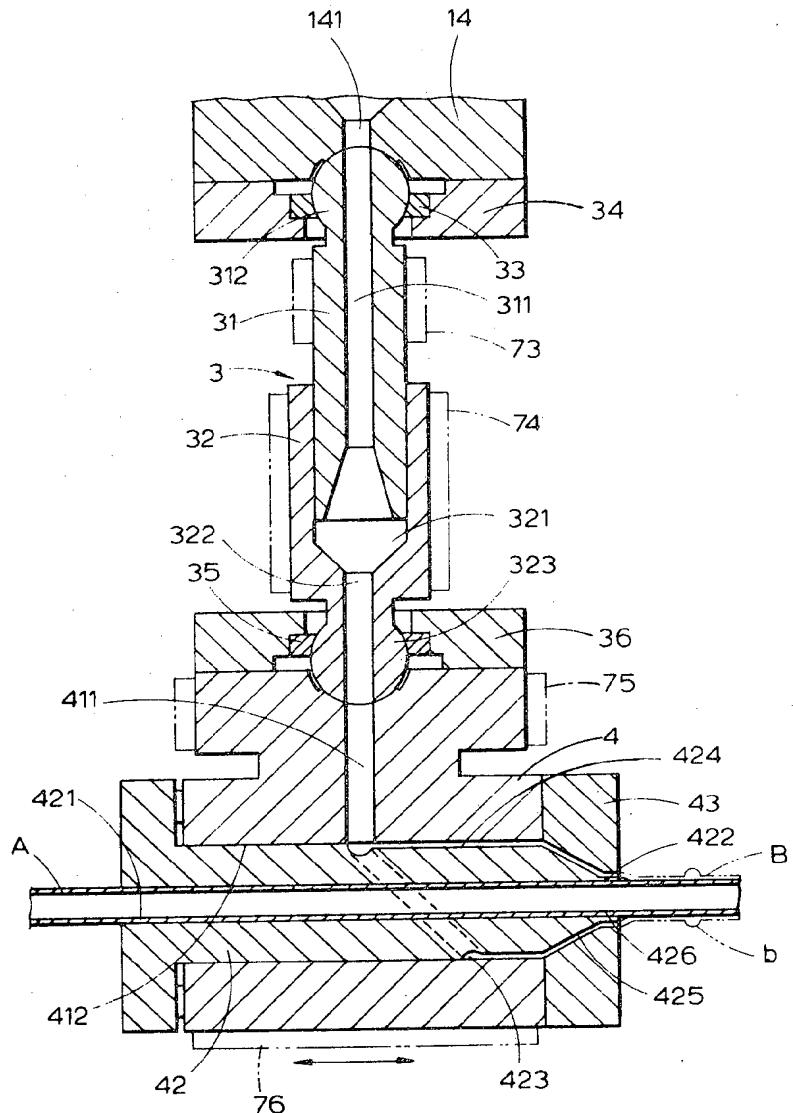


Fig. 2.

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**Fig. 3.**

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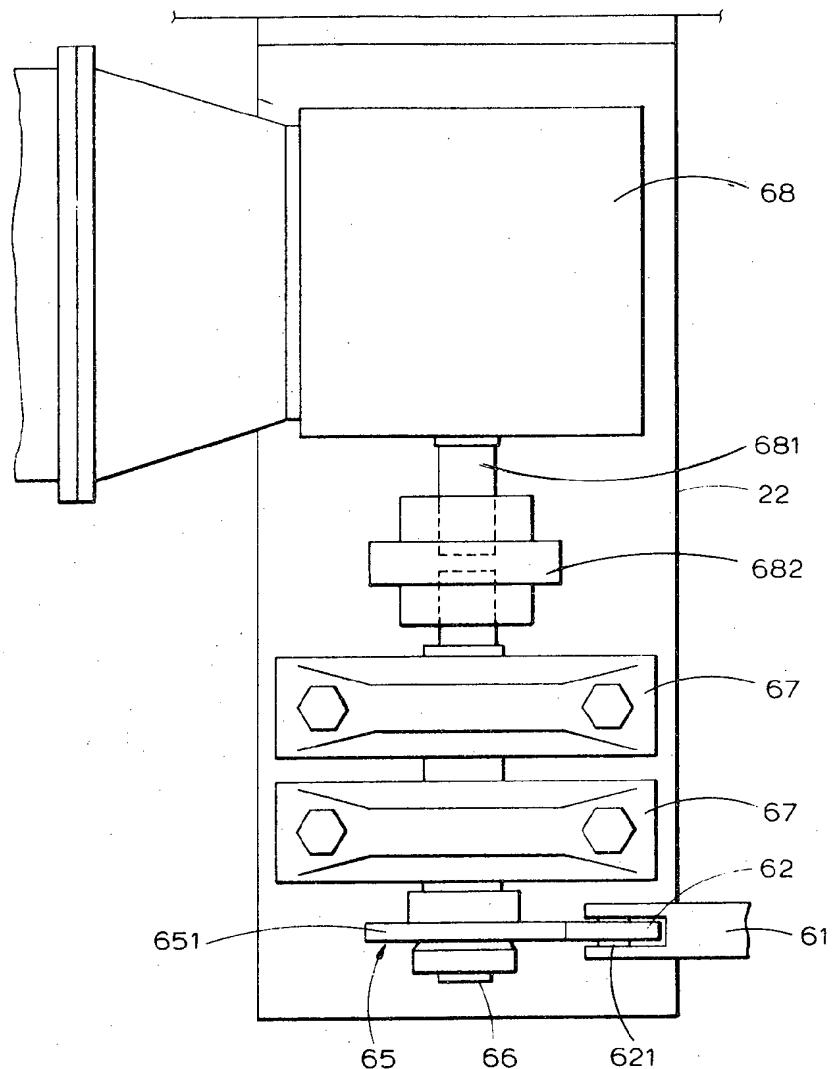


Fig. 4.

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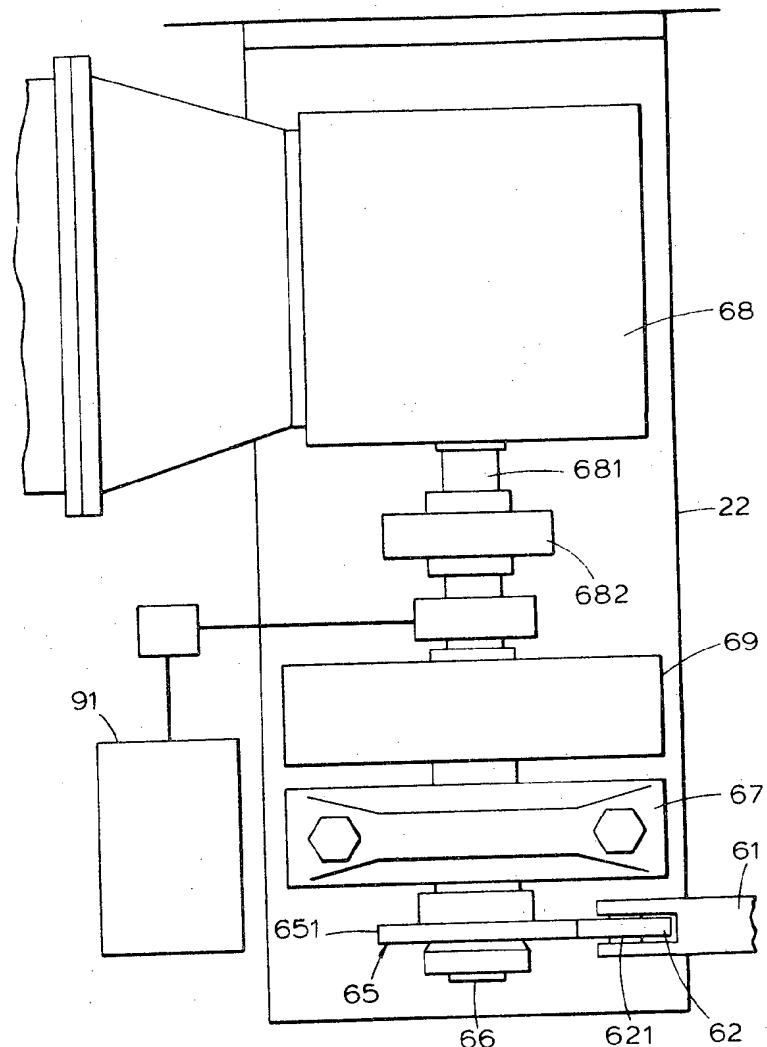


Fig. 5

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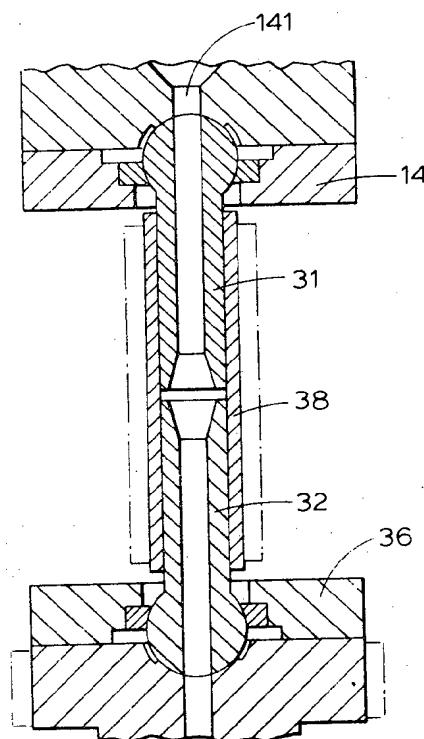


Fig. 6A

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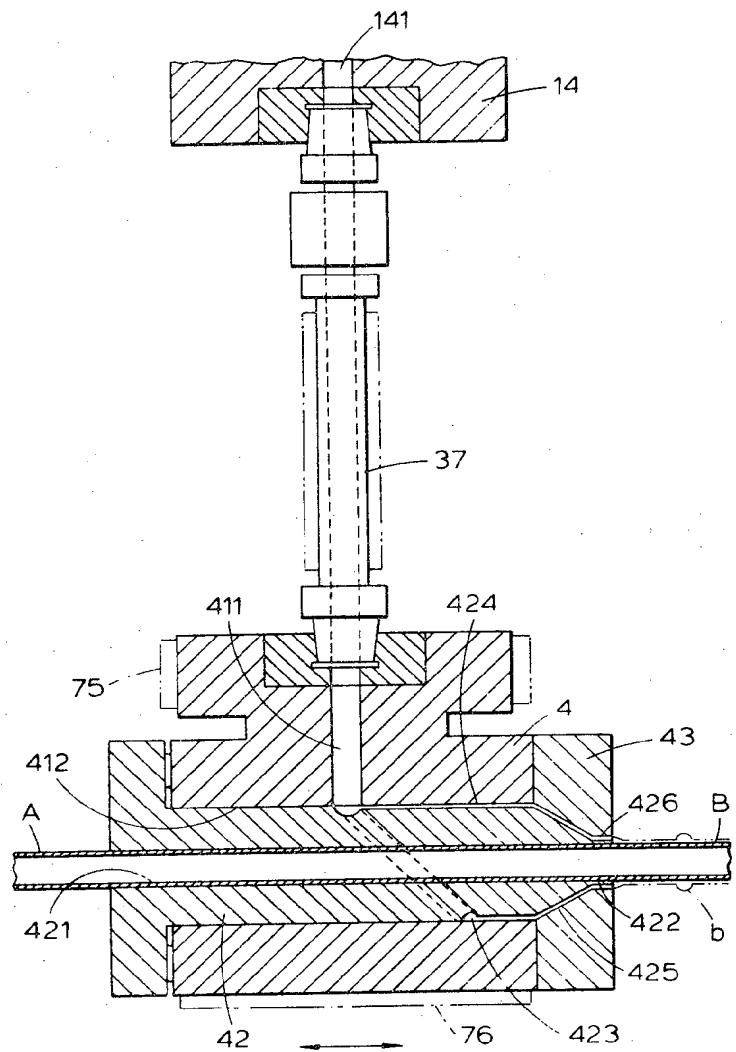


Fig. 6B

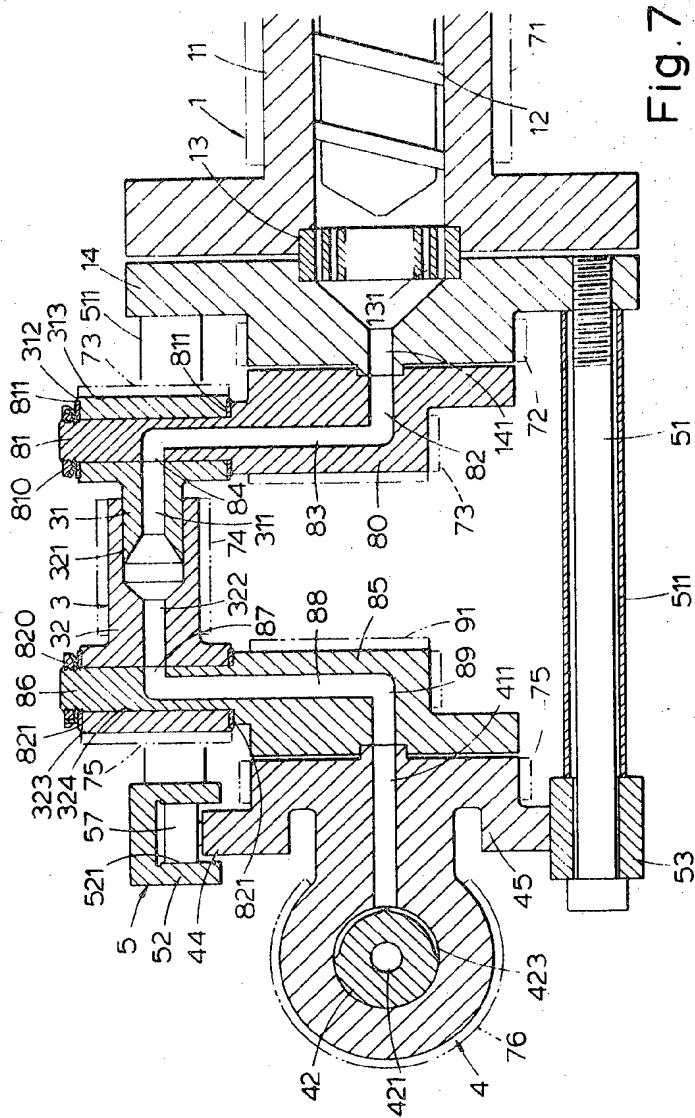
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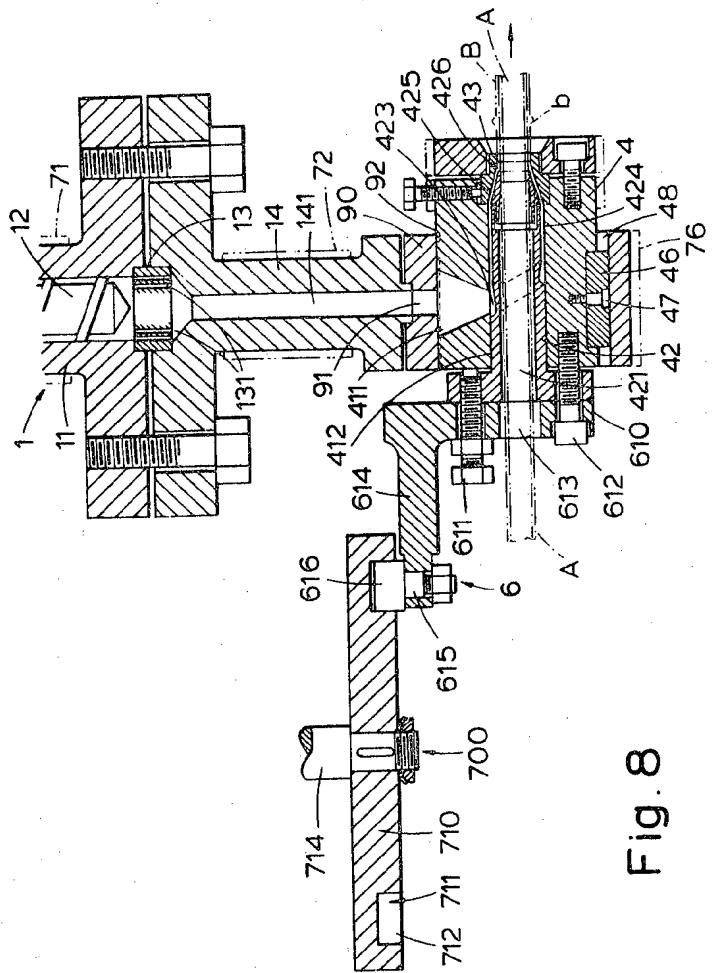
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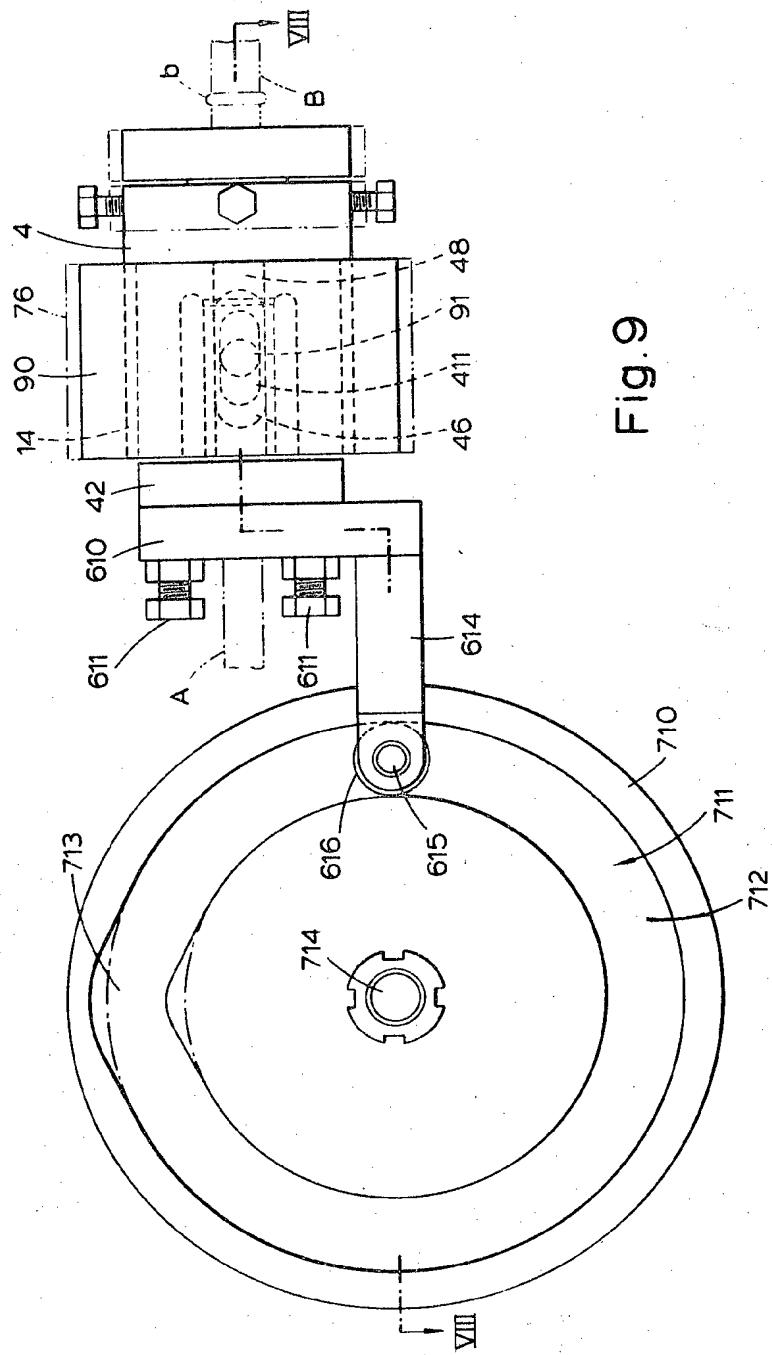


Fig. 9